June 8, 2017

BY ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: ***Actions to Accelerate Adoption and Accessibility of Broadband-enabled Health Care Solutions and Advanced Technologies*, GN Docket 16-46**

Dear Ms. Dortch:

On June 7, 2017, Hughes Network Systems, LLC ("Hughes") met with members of the Connect2Health Task Force ("Task Force") to discuss Hughes's filing in the above-referenced proceeding. Hughes was represented by Jennifer A. Manner, Senior Vice President, Regulatory Affairs and Jodi Goldberg, Associate Corporate Counsel, Regulatory Affairs. Representatives of the Task Force included Louis Peraertz, Karen Onyeije, Dr. Chris Gibbons, Ben Bartolome (by phone), Dr. Yahya Shaikh (by phone), and David Ahern (by phone).

In the meeting Hughes provided the Task Force with a basic overview of the Hughes service offering, including the recently launched EchoStar XIX high-throughput geostationary broadband satellite and its capabilities. Hughes further explained the relationship between satellite broadband services and latency, the concerns that are often raised by regulators when discussing those services, and how latency over satellite broadband would pertain to telehealth services. Hughes and the Task Force also discussed the attached talking points, which summarize the White Paper Hughes filed in response to the above-referenced proceeding, as well as a paper by Andre Boik, of the Economic Department at the University of California Davis, exploring the shortcomings of subsidies that support availability of broadband to encourage consumer adoption, which is also attached.

Pursuant to the Commission's rules, this notice is being filed in the above-referenced docket for inclusion in the public record. Please contact me should you have any questions.

Respectfully submitted,

/s/ *Jodi Goldberg*

____

Jodi Goldberg
Associate Corporate Counsel, Regulatory Affairs
Hughes Network Systems, LLC
11717 Exploration Lane
Germantown, MD 20876
(301) 428-7140

cc: Ben Bartolome
Louis Peraertz
Karen Onyeije

SATELLITE BROADBAND IS AN ESSENTIAL COMPONENT IN ENABLING HEALTHCARE CONNECTIVITY THROUGHOUT THE UNITED STATES

***Actions to Accelerate Adoption and Accessibility of Broadband-enabled Health Care Solutions and Advanced Technologies*, GN Docket 16-46**

June 2017

- Hughes Network Systems, LLC (Hughes) is the largest provider of satellite broadband services throughout North America, serving over one million users, including those in rural, remote, and tribal areas.

- Earlier this year, Hughes began providing commercial service from EchoStar XIX, the world's highest throughput satellite. The satellite provides Commission-defined broadband speeds of 25/3 mbps for residential users, and 55/5 mbps for enterprise users, throughout the continental United States and southern Alaska. With the addition of EchoStar XIX, Hughes is now able to offer more than double the capacity of its previous two-satellite configuration and deliver the highest quality broadband services to Americans, wherever they live. Over the past two months, EchoStar XIX has surpassed 100,000 subscribers for its new service.[1]

Satellite Broadband provides ubiquitous coverage of the Unites States, increasing access to reliable, cost-effective, high speed broadband services that are critical for the delivery of broadband-enabled healthcare solutions.

- <u>Wide Area Coverage</u>: nationwide coverage requires minimal ground infrastructure; a total of 43 gateways in the United States is required for Hughes to provide reliable, high-speed broadband services across the Continental United States and southern Alaska. All that is required for customer connectivity is a small antenna, which can be installed in a matter of days.

- <u>Reliability</u>: located 22,300 miles above the Equator, geostationary orbit satellites are not as vulnerable to natural and manmade disasters as terrestrial networks, making them critical components for emergency response services and the delivery of telehealth services.

- <u>Cost-Efficiency</u>: there is no costly fiber buildout to each individual user, making it easily and efficiently deployable in more dispersed regions of the country.

These three traits make satellite broadband a foundational platform for ensuring sufficient broadband capacity is available and accessible to both health care providers and patients in communities throughout the United States in order to facilitate the increased demand for broadband-enabled healthcare solutions.

- Broad coverage offered by satellite services makes them ideal providers for dispersed networks, such as integrated hospital networks that have multiple facilities throughout a

[1] Press Release: "HughesNet Gen5 Surpasses 100,000 Subscribers In Just Two Months", June 5, 2017. Available at: http://www.prnewswire.com/news-releases/hughesnet-gen5-surpasses-100000-subscribers-in-just-two-months-300468274.html

region, state, or even the country. Hughes, and other satellite providers, have decades of experience in designing Virtual Private Networks (VPNs) that can protect sensitive patient information while offering nationwide integrated solutions for primary care facilities that utilize Cloud-based services for treatment of patients and transmission of patient records between providers.

- Ubiquitous satellite coverage increases the ability of communities to adopt remote patient monitoring programs, as cost-efficient broadband is available to both the health care facility and the patient at home. Once a patient has a broadband connection, a health care provider will also be able to provide them will additional services, including high quality voice and videoconferencing services for interfacing with their primary care practitioners without leaving home.

- Satellite broadband offers "always on" reliability, further enabling patients to connect with healthcare providers at any time, regardless of weather or the perceived security of their surroundings. In this sense, satellite networks can be utilized as the primary service connection for a community, and it can also offer path diversity for critical communication networks to ensure that there are no service outages that disrupt connectivity between patients and care providers.

In order to continue to meet the increased demand for reliable and cost-effective access to broadband services, satellite broadband providers encourage the Commission to pursue technology neutral regulations relating to spectrum allocation and funding distribution.

- <u>Spectrum</u>: Telehealth services have varying demands for spectrum resources, from low data patient monitoring to high-speed, real-time video conference to future broadband-facilitated treatments, such as robotic surgery. Like all telecommunications platforms, satellite providers require sufficient access to the spectrum resource to meet the rising consumer demands for telehealth services. Regulators must ensure that spectrum allocations are technology neutral, to facilitate competition between platforms so that no single technology is benefitted with access to spectrum to the detriment of other services.

- <u>Funding</u>: As with the spectrum resource, there is no expectation that funding be equally allocated among competing platforms, however, it is imperative that the funding regime adopted embrace competition among platforms. Where funding is made available to certain platforms and not others, or certain platforms are heavily penalized for attributes that are less relevant when they are the only service provider in a region, less connected communities will continue to lag behind in technology adoption. This will be ever more evident in communities that rely on broadband connectivity for the provision of healthcare services.

Satellite Broadband offers communities throughout the United States the opportunity to access advanced broadband-enabled healthcare solutions today.

The Economics of Universal Service: An Analysis of Entry Subsidies for High Speed Broadband

Andre Boik*
University of California, Davis

(*Last updated: September 30, 2015*)

Results are very preliminary

Abstract

Universal service is a policy objective that all individuals or households have access to some service. Subsidy policies to accomplish universal service may arise when private provision is non-universal. In the context of rural high speed wired broadband subsidies, this paper exploits household-level cable and satellite broadband subscription data from North Carolina to examine household adoption and substitution patterns and to evaluate how many currently unserved regions warrant an entry subsidy. This paper has three main findings: (i) fewer than 47% of households adopt high speed broadband in areas currently served by a single broadband provider, (ii) there exists a significant elasticity of substitution between high speed wired broadband and the lower speed options of satellite broadband and DSL, and (iii) a generous upper bound on the number of regions that warrant an entry subsidy is 67%. These results suggest a policy of universal service in North Carolina would be unlikely to achieve universal adoption, would connect many households already with internet access and who would not substitute, and in many regions would be prohibitively costly even assuming very generous estimates of the consumer surplus generated. From the perspective of social welfare, to connect the 5% least dense areas of North Carolina would require each adopting household value broadband access at more than $1550 per month.

Keywords: Universal service, entry subsidies, broadband, telecommunications
JEL Classification: L96, L97, L51, H71

1 Introduction

Universal service policies arise from an equilibrium in which private firms choose not to serve all consumers. In the context of goods delivered through wired infrastructure to the household, firms choose not to extend their wired network to all geographic areas. In this equilibrium, the two primary theoretical justifications for government provided subsidies are the existence of (positive)

*Department of Economics, University of California, One Shields Avenue, Davis CA, 95616, aboik@ucdavis.edu. I would like to thank Shane Greenstein, Laura Grigolon, Han Hong, Erich Muehlegger, Jeff Prince, Glen Weyl, and Brad Wimmer for very helpful comments and especially Jennifer A. Manner for several extensive discussions. I would also like to thank Daniel Covrig, Sinath Neang, Jean Stratford, and Thinh Tran for excellent research assistance. I gratefully acknowledge financial support from the NET Institute (www.NETinst.org).

network externalities, or that private infrastructure costs lie in a region where they exceed variable profits but not variable profits plus consumer surplus (Goolsbee, 2002). In the case of the former, the prescribed policy is a per unit subsidy up to the marginal positive externality created by an additional user, and in the case of the latter, an entry subsidy up to the amount of consumer surplus not extracted by the private provider.

To evaluate these subsidy schemes in the simplest setting requires estimates of consumer surplus and the cost of expanding the existing infrastructure.[1] While universal access is a prerequisite for universal service, universal adoption is also required to meet the objective. This paper examines the extent to which universal adoption would occur in geographic areas currently without access to high speed wired broadband, and for which subsidies have been considered to the extent of 1.8 billion U.S. dollars per year. To do so, I exploit novel data regarding household-level adoption decisions provided to me by the largest satellite broadband provider in the United States as well as data collected from the fourth largest cable provider in the United States. I present three sets of results: (i) the facts of household-level adoption in regions that exhibit the market structure that would prevail in currently unserved regions after subsidized entry, (ii) evidence of low willingness to pay for high speed broadband among an economically significant number of households that currently accept slower broadband (DSL and satellite), and (iii) estimates of an upper bound on the number of regions qualifying for a welfare improving entry subsidy.

In my empirical setting of North Carolina, I am able to characterize broadband adoption decisions (not including DSL, wireless, other) for many regions at the household level. The regions currently served by a single high speed wired broadband provider are most of interest because they have the market structure that would prevail in currently unserved regions were subsidized entry to take place. The high speed wired broadband provider of interest is Charter Communications, as of 2014 the fourth largest cable provider in the United States. In North Carolina's regions where Charter is a monopolist of high speed wired broadband, only 47% of households adopt. The remaining households choose either satellite broadband (1.4%), DSL, wireless, or no access at all. I do not find any evidence to suggest adoption would be higher in currently unserved regions in response to an expansion of the wired broadband footprint.

At the time of writing, Charter Communications does not vary its broadband prices across regions in North Carolina nor do most of its rivals. In the absence of price variation, it is difficult to identify the curvature of demand to estimate consumer surplus or the elasticity of substitution towards slower speed technologies. Instead, I identify one measure of effective price variation at the household level (whether the dwelling is a modular/manufactured home) and one measure of the quality of a slower form of broadband access (distance to the nearest DSL distribution facility). Modular homes are frequently built without pre-wiring for cable or telephone lines: households dwelling in such homes face an additional one-time cost of adopting wired internet access in the range of a few hundred dollars. I find that households dwelling in modular homes, conditional on the value of the home, are 17-23% less likely to adopt wired broadband despite the amortized monthly cost of connection being quite low. This result is not consistent with the claim that such households tend to have lower disposable income to expand on internet access because such households are at least 43% *more* likely to adopt satellite broadband. Secondly, households located within 5 kilometres of a DSL distribution

[1] More complicated settings would involve predicting the arrival of new and superior technologies, how to allocate those subsidies across firms, circumstances under which subsidies would cease, etc.

facility (the effective radius of the range of DSL broadband) are 13-26% less likely to adopt cable and at least 14% less likely to adopt satellite broadband. Further, households within this radius are less likely to adopt either cable or satellite broadband the closer they are located to the DSL distribution facility. This evidence indicates that households are willing to substitute between cable broadband and DSL, and suggests that if access to high speed wired broadband is expanded that many households will continue to adopt slower technologies already available to them. While it is natural to expect satellite adoption to decline with proximity to a DSL distribution facility since such facilities are usually located in cities, it is difficult to provide an alternative hypothesis for why cable adoption also declines in proximity to DSL facilities and in comparable magnitude.

While Nevo et. al (2015) studies the intensive margin of high speed broadband, I examine the extensive margin since evaluating entry subsidies requires estimates of how many households will actually adopt high speed broadband to begin with. Nevo et. al (2015) provide a number of estimates of consumer surplus conditional on adoption of fibre-to-the-home broadband that delivers download speeds of 1GB/s and at various prices. Using the most generous of these monthly consumer surplus estimates, $279 for 1GB/s at a price of zero, I find that at most 67% of unserved census block regions in North Carolina warrant an entry subsidy to provide broadband quality comparable to urban areas. The estimate of 67% is a firm upper bound: the consumer surplus figure used is based on a much higher quality of broadband and a much lower price than what currently exists in most urban areas. The fraction of census block regions qualifying for an entry subsidy would have to be adjusted downward by a more accurate estimate of the prevailing consumer surplus in urban areas.

2 Data

I combine two novel household-level datasets with other publicly available data to examine households' broadband decisions conditional on the choices available to them. The data are summarized in Table 1. Because I require the full sample of households that may or may not subscribe to high speed broadband, the sample area is restricted to the state of North Carolina, the only state which publishes its entire Master Address File. The Master Address File is a complete list of North Carolina addresses as well as their latitude/longitude location. HughesNet, the satellite broadband provider with the largest market share and which offers the fastest speeds, has provided me with subscriber data including their location and speed chosen. Household-level subscriber data for Charter Communications, the fourth largest cable provider in the United States as of 2014, was obtained via web scraping in November, 2014. This data indicates for every address in North Carolina whether that household subscribes to Charter, though I do not observe at what speed.[2] The National Telecommunications and Information Administration (NTIA) database indicates the available options for broadband at the census block level. Combining these data allows me to characterize the high speed broadband decisions of all households in 19.5% of North Carolina's 247,253 census blocks.[3]

[2]The subscriber count I obtained from scraping Charter's website matches well with publicly disclosed subscriber counts. It is important to note, however, that a household discovered to subscribe to Charter may have only subscribed to television or home phone and not internet and therefore I have an overestimate of the number of Charter *broadband* subscribers.

[3]DSL, fixed wireless and other slower technologies are not considered broadband and therefore are not tracked by the NTIA.

3 Household broadband adoption patterns across regions

Charter adoption rates across regions are illustrated in Figure 2. Adoption varies significantly across census blocks and census tracts, with a mean of 47%. This variance exists not only across all regions of North Carolina but also within regions where households have the same choice of broadband provider. There is little evidence to suggest that variance in Charter adoption is driven by price or service quality variance across regions. First, Charter's website quotes all households in North Carolina the same prices and while private discounts may exist, the discounts would have to vary even within regions where households have the same choice of broadband provider to explain the variance in adoption. Second, it is well known that the quality of broadband provided via (coaxial) cable does not degrade meaningfully with distance so that adoption of Charter does not vary across regions because some are further from distribution facilities.

This evidence suggests that the variance in Charter adoption is driven in part by demand side factors. In regions where Charter competes with at least one other provider, adoption of Charter is actually 5% higher. Since the causal effect of competition on Charter adoption is certainly negative, this suggests demand for broadband is higher in these areas.[4] The existing literature has consistently identified high income, white racial background, education, and younger age groups as factors that are positively associated with internet adoption (Rosston et al., 2010).

In Section 4, I document that the availability of DSL and whether a given dwelling is a manufactured home partially explains some of the variance in adoption rates. Manufactured homes are often not pre-wired for telephone or cable which creates an additional cost for a household to adopt internet access. I also exploit household distance to the nearest DSL provider's distribution facility to document evidence of a substantial number of households adopting DSL despite being an unambiguously lower quality product compared to high speed cable broadband. Broadly speaking, these results suggest that because overall valuations for internet access vary across households as do preferences over connection types, that if universal service is accomplished, adoption rates will be less than universal because of heterogeneity in the utility from internet access as well as in connection type.

4 Household substitution patterns across cable, DSL, and satellite

Define u_{hj} as household h's utility from purchasing broadband from provider j. Let $u_{hj} = X_h\beta + \varepsilon$ where X_h is a vector of household characteristics and $\varepsilon \sim N(0, \sigma^2)$. The probability of the household purchasing option j is $Pr(u_{hj} > u_{h-j})$. I focus on two providers, Charter Communications and (HughesNet) satellite broadband, and household characteristics include whether the dwelling is a manufactured home, distance to the nearest DSL distribution facility, the number of rival broadband providers present, property value of the home, and the year the home was built. For now a full discrete choice model is not presented; instead, the probability of purchasing option j is treated independently of the other options and estimated via probit for illustrative purposes.

[4] An alternative explanation for this finding is that competition causes Charter to either target secret discounts to households or to increase its speeds in specifically those regions. While I cannot rule out systematic secret discounting to households in competitive regions, Figure 2 illustrates that there exists as much variance in adoption within competitive regions as there is in regions where Charter does not face competition from a wired broadband provider

Table 3 presents the estimates of a probit estimation relating Charter adoption to household characteristics. Log(Distance to DSL) measures in kilometres the distance of the home to the nearest DSL distribution facility; a 1% increase in distance from the nearest DSL facility increases the probability of Charter adoption by roughly 0.05%, but only within the 5 km range of the DSL facility as expected. Outside of that range, the probability of a household adopting Charter is 6-12% higher. The probability of a household dwelling in a manufactured home adopting Charter is 8-11% lower than for non-manufactured homes. Newer homes and homes with higher property values are both associated with higher probabilities of Charter adoption. An increase in a home's value by $100,000 is associated with a 5-6% higher probability of adopting Charter, and a home that is ten years newer is associated with a 2-3% higher probability of adopting Charter.

Table 4 presents the estimates of a probit estimation relating HughesNet satellite adoption to household characteristics. A 1% increase in distance from the nearest DSL facility increases the probability of satellite adoption by 0.0003%, but only within the 5 km range of the DSL facility. Outside of that range, the probability of a household adopting HughesNet is 0.1-0.3% higher. The probability of a household dwelling in a manufactured home adopting satellite is 0.3-0.7% higher than non-manufactured homes. A home that is ten years newer is associated with a 0.04% increase in the probability of adopting satellite, while there is no relationship between the value of the home and satellite adoption. While these magnitudes appear small, they must be compared to the mean probability of satellite adoption which is only 0.07 compared to the mean probability of Charter adoption of 0.47. On that basis, the magnitudes of the key estimated effects are very comparable, especially for the effect of dwelling in a manufactured home which has a negative effect on Charter adoption and an almost identical but positive effect on satellite adoption as expected.

Since I only observe each household's binary adoption decision and not the latent utility from adoption, I can only estimate each household's surplus from adoption up to scale. Intuitively, if a household has characteristics that make adoption probable then that household likely has a higher latent utility from adoption. These adoption probabilities do not vary significantly across served and unserved regions. However, a much richer set of household characteristics is necessary to make this conclusion confidently, particularly the characteristics frequently identified in the literature as being important. The household characteristics considered, while significant, explain only 3% of the variance in adoption.

5 Estimates of census block regions warranting a welfare improving subsidy

A private broadband provider will only enter a market if the expected profits are greater than the fixed cost of entry, whereas from a social welfare point of view, entry should occur whenever expected profits plus consumer surplus are greater than the fixed cost of entry. Therefore the scope for entry subsidies is closely tied to consumer surplus and the extent to which broadband providers can capture it. I identify the fraction of North Carolina census blocks warranting an entry subsidy by exploiting variation in the fixed cost of entry driven by household density, the entry decisions of existing providers, and estimates of consumer surplus taken from Nevo et. al (2015) for 1GB/s download speed quality broadband.

All else equal, the fixed cost of entry should be linear in household density. If the homes of one region are twice as spread out as homes in another region, the fixed cost of entry is expected to be twice as large in the former region compared to the latter. The entry patterns of existing providers presented in Table 5 strongly confirms this pattern: density is a major factor explaining the number of providers in a region. To be specific, 31% of the variation in the number of providers is explained by household density alone. I take the regions with a single provider to be regions where private variable profits are closest to the fixed cost of entry. This is a proxy for the density level at which firms break even, under the assumption of homogeneous household surplus and adoption rates across regions.[5] This break even density level is approximately 160 households per square kilometre. In order to induce a firm to enter a region with a lower density, d, the firm will require a per-household subsidy of $(\frac{160}{d} - 1)p$ where p is the prevailing uniform price for broadband and taken to be $40, the price of Charter's most popular broadband package. Following Goolsbee (2002), the maximum subsidy that should be *offered*, however, cannot exceed the average adopting household's consumer surplus. Estimates of the average adopting household's consumer surplus are taken from Nevo et al. (2015).

Table 6 calculates, under different estimates of consumer surplus, an upper bound on the fraction of currently unserved census block regions with a density high enough to induce a provider to enter with an entry subsidy not exceeding consumer surplus in the region. The consumer surplus estimates vary from $175 to $279 under different assumptions regarding pricing and what other alternative speeds are available. For my purposes, $279 is an estimate very generous to finding a larger share of qualifying regions since it represents the consumer surplus of 1GB/s speeds offered at a price of zero. Using this most generous estimate of consumer surplus, fewer than 67% of currently unserved regions in North Carolina qualify for a welfare improving entry subsidy. Under the least generous estimate of consumer surplus, $175, fewer than 52% qualify.

Table 7 shows the marginal subsidy expenditure required to expand service to a given percentage of currently unserved regions. The marginal subsidy cost of expanding service to the 90% least dense area of North Carolina is $789 per month. To connect the 99% least dense area of North Carolina would require a monthly subsidy of $4729. Since these figures are well above the most generous estimate of consumer surplus, $279 per month, I find that a policy of full universal service is not warranted in North Carolina.

6 Conclusion

Universal service policies seek to achieve universal access to some service, but it is another matter whether universal adoption of that service will occur. In the context of universal service policies to expand high speed wired broadband to rural areas, this paper documents the internet adoption patterns from a sample of North Carolina's roughly 4.5 million households. Not surprisingly, household adoption patterns vary widely across regions in North Carolina even after controlling for the broadband options available, suggesting that demand and therefore underlying household valuations for broadband vary from household to household. In particular, in semi-rural areas where a leading cable provider (Charter Communications) is a monopolist seller of high speed wired broadband, adoption is less than 47%.

[5] Regions within 1 kilometre of the border are another natural region to assume the minimum density which can sustain a single provider but it is irrelevant because the densities are virtually identical in either case.

While universal access may be achieved in North Carolina, it is unreasonable to expect universal adoption. I document evidence that there is a substantial margin of elasticity between high speed wired broadband and other slower forms of internet access: DSL and satellite broadband. Specifically, household dwellings that are manufactured homes are approximately 17-23% less likely to adopt high speed wired broadband because manufactured homes are often not pre-wired for cable or telephone. Consistent with this claim, and not that households dwelling in manufactured homes are linked to demographics correlated with low willingness to pay for internet access, these same households are at least 43% more likely to adopt satellite broadband since the relative cost of connection is lower.

Similarly, households within 5 kilometres of a DSL distribution facility (the effective range of DSL) are approximately 13-26% less likely to adopt Charter, evidence that households are willing to substantially trade off the higher speeds of cable broadband for features specific to the DSL provider such as potentially lower price. Consistent with this claim, households are more likely to adopt Charter the further the household is located from the DSL distribution facility within this 5 kilometre radius. These results are conditional on the choice sets of high speed broadband providers available, the property value of the dwelling and its year of construction.

Under very generous assumptions regarding the surplus that households receive from high speed broadband, I estimate that no more than 67% of currently unserved regions of North Carolina warrant an entry subsidy. This estimate is a firm upper bound since it is based upon a consumer surplus estimate of 1GB/s download speeds offered at a zero price. In contrast, the current entry subsidy scheme favored by the Federal Communications Commission requires providers offer only 10MB/s download speeds and at prices comparable to urban areas. Not surprisingly, a policy of full universal service in North Carolina does not meet the welfare standards prescribed by Goolsbee (2002). To justify serving the 10% least dense areas of North Carolina requires that the average adopting household have a monthly valuation of over $789 per month.

It remains unclear whether alternative forms of subsidy policies are warranted. Goolsbee (2002) favors entry over per-unit subsidies because per-unit subsidies attract marginal to low valuation adopters. However, in the context of internet adoption, Goldfarb and Prince (2008) show that while low income households are less likely to adopt, if they do adopt then their usage is higher since they observe an effectively zero usage price. On the other hand, Carare et. al (2014) find from survey data that roughly two-thirds of non-adopters have a zero willingness to pay for high speed broadband. Future work that creates a tighter link between adoption on the extensive margin, usage on the intensive margin, and the exact source of network externalities in the context of optimal subsidy policy is warranted.

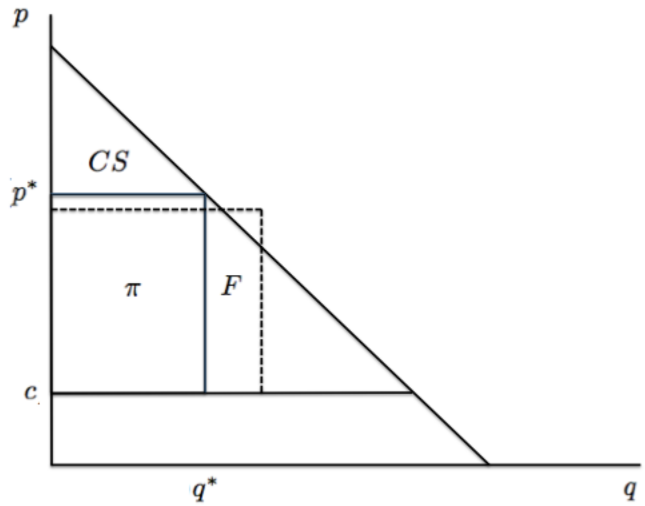

Figure 1: Scope for an entry subsidy when $CS + \pi > F > \pi$

Table 1: Data Sources

Description	Level of Observation	Source	Time Period	Number of Observations
Satellite subscribers	Household	HughesNet	September, 2014	2x,xxx
Charter subscribers	Household	Web Scraping	November, 2014	122,053
Choice Set	Census Block	NTIA	2014	247,253
Master Address File	Household	State of NC	2014	4,766,652

NTIA Broadband Map available at http://www2.ntia.doc.gov/broadband-data
Master Address File available at http://www.cgia.state.nc.us/Services/NCMasterAddress.aspx

Table 2: Summary Statistics

Variable (Household-Level, Charter Regions)	Obs	Mean	Std Dev	Min	Max
Charter Subscriber Dummy	129,391	0.47	0.50	0	1
Number of Providers	228,308	1.89	0.56	0	4
Manufactured Home Dummy	142,084	0.04	0.19	0	1
log(Distance to DSL)	228,308	2.60	1.30	-5.28	5.54
{Distance to DSL > 5 km}	228,308	0.82	0.50	0	1
Home Value	127,221	169,656	174,054	10,000	13,826,540
Year Built	126,117	1970	27	1900	2015
Variable (Household-Level, All Regions)	**Obs**	**Mean**	**Std Dev**	**Min**	**Max**
HughesNet Subscriber Dummy	3,065,438	0.007	0.08	0	1
Number of Providers	3,053,878	1.89	0.89	0	5
Manufactured Home Dummy	278,751	0.06	0.24	0	1
log(Distance to DSL)	3,041,390	3.05	1.26	-4.39	5.54
{Distance to DSL > 5 km}	3,065,438	0.85	0.35	0	1
Home Value	267,744	209,355	287,420	10,000	21,500,000
Year Built	260,908	1982	24.33	1900	2015

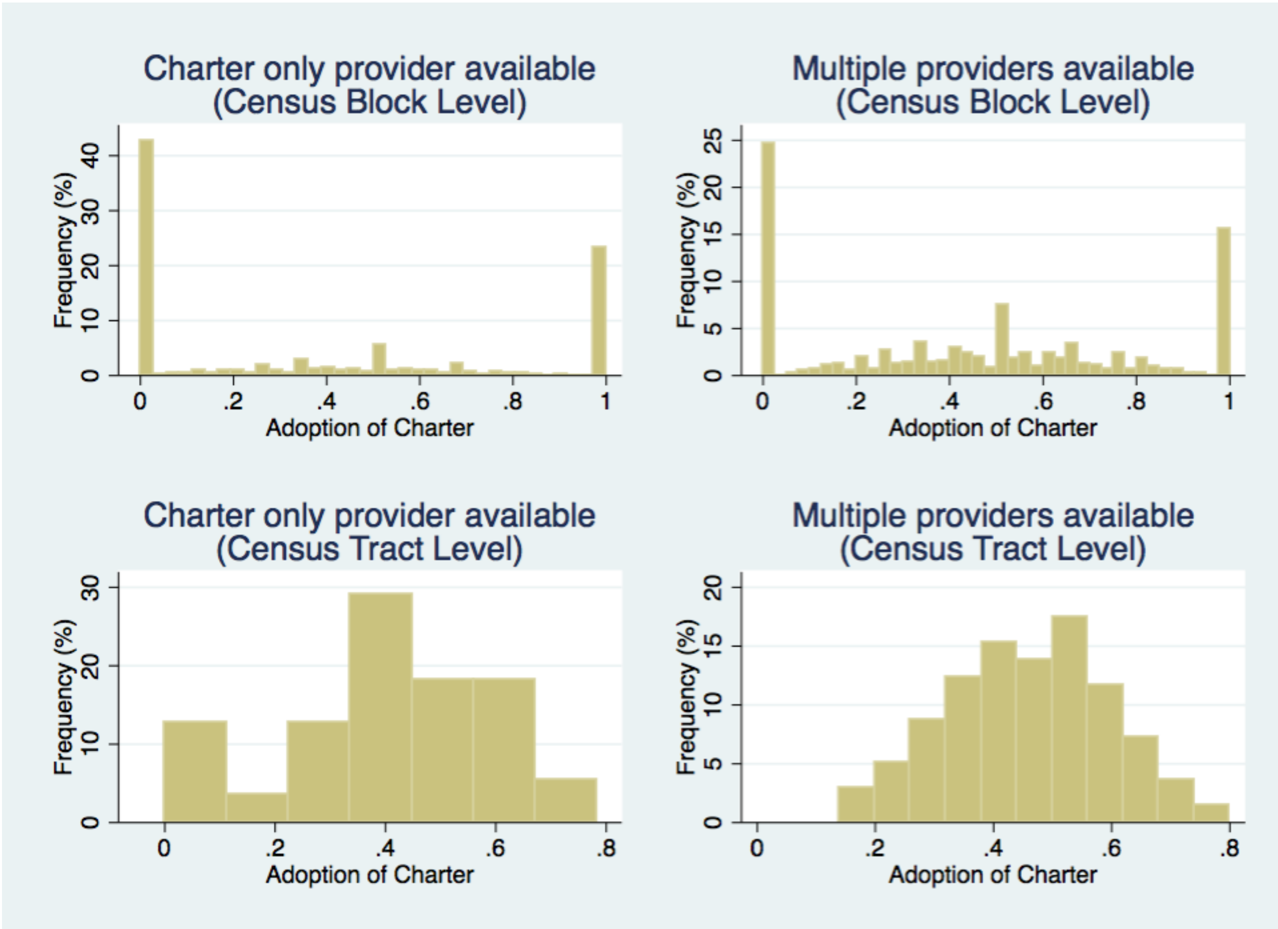

Figure 2: Variance of Charter adoption across regions

Table 3: Dependent variable is whether a household purchases Charter Communications broadband or not. Estimated via probit. Standard errors clustered at the census block level.

	(1)	(2)	(3)	(4)
Number of Providers	-0.00	0.03*	-0.25***	-0.09***
	(0.04)	(0.02)	(0.05)	(0.02)
log(Distance to DSL)/1000	141.65***	141.59***	102.40***	128.50***
	(21.92)	(21.92)	(24.02)	(23.79)
{Distance to DSL $>$ 5 km}		0.14***		0.29***
		(0.04)		(0.04)
log(Distance to DSL)/1000 x {Distance to DSL $>$ 5 km}		-145.96***		-189.96***
		(24.27)		(26.40)
Manufactured Dummy			-0.21**	-0.29***
			(0.09)	(0.03)
(Home Value)/1000			0.12***	0.06***
			(0.03)	(0.01)
(Year Built)/10			0.04***	0.03***
			(0.01)	(0.00)
Constant	-0.20***	-0.27***	-7.74***	-6.48***
	(0.08)	(0.04)	(1.28)	(0.61)
Only within 5km of DSL	Yes	No	Yes	No
R-Squared	0.00	0.02	0.01	0.05
N	26,654	129,391	17,617	79,340

Marginal effects of key variables evaluated at mean	(1)	(2)	(3)	(4)
log(Distance to DSL)	0.06***	0.06***	0.04***	0.05***
Manufactured Dummy			-0.08**	-0.11***
{Distance to DSL $>$ 5 km}		0.06***		0.12***
(Home Value)/100000			0.05**	0.06***
(Year Built)/10			0.02***	0.03***

Table 4: Dependent variable is whether a household purchases HughesNet satellite broadband or not. Estimated via probit. Standard errors clustered at the census block level.

	(1)	(2)	(3)	(4)
Number of Providers	-0.16***	-0.23***	-0.38***	-0.36***
	(0.01)	(0.00)	(0.04)	(0.01)
log(Distance to DSL)/1000	37.80***	34.09**	95.01**	95.46**
	(14.55)	(14.75)	(46.35)	(47.19)
{Distance to DSL > 5 km}		0.13***		0.27***
		(0.02)		(0.07)
log(Distance to DSL)/1000 x {Distance to DSL > 5 km}		-53.85***		-117.70**
		(15.37)		(48.42)
Manufactured Dummy			0.22**	0.30***
			(0.10)	(0.03)
(Home Value)/100,000			-0.01	-0.00
			(0.02)	(0.01)
(Year Built)/10			0.02*	0.02***
			(0.01)	(0.00)
Constant	-2.44***	-2.30***	-5.84**	-6.37***
	(0.03)	(0.02)	(2.31)	(0.77)
Only within 5km of DSL	Yes	No	Yes	No
R-Squared	0.00	0.02	0.01	0.05
N	651,301	4,529,047	34,173	254,397

Marginal effects of key variables evaluated at mean	(1)	(2)	(3)	(4)
log(Distance to DSL)	0.0003*	0.0004*	0.001**	0.001*
Manufactured Dummy			0.003*	0.007***
{Distance to DSL > 5 km}		0.001***		0.003***
(Home Value)/100000			-0.0002	-0.0001
(Year Built)/10			0.0002	0.0004***

Table 5: Density as a major determinant of the number of broadband providers

Number of Providers	Average Density (Households per km^2)
0	58
1	126
2	274
3	495
4	565
5	1216

Table 6: Fraction of regions in North Carolina warranting an entry subsidy as a function of consumer surplus estimates (conditional on adoption)

Estimate of monthly CS	Fraction of regions qualifying for subsidy
$175	.52
$194	.55
$213	.58
$279	.67

Table 7: The subsidy cost per-adopting household as a function of the desired coverage of the broadband footprint in currently unserved regions of North Carolina

Desired coverage	Required monthly subsidy
50%	$164
67%	$279
75%	$375
90%	$789
95%	$1550
99%	$4729

7 References

Carare, O., McGovern, C., Noriega, R., and Schwarz, J. 2014. "The Willingness to Pay for Broadband of Non-Adopters in the U.S.: Estimates from a Multi-State Survey", FCC Working Paper.

Goldfarb, A., and Prince, J. 2007. "Internet Adoption and Usage Patterns are Different: Implications for the Digital Divide." *Information Economics and Policy*, 20, 2-15.

Goolsbee, A. 2002. "Subsidies, the Value of Broadband, and the Importance of Fixed Costs", Broadband: Should we Regulate High-Speed Internet Access?, Robert Crandall and James H. Alleman, eds. 278-294, Brooking Institution Press (Washington, D.C.)

Nevo, A., Turner, J., and Williams, J. 2015. "Usage-Based Pricing and Demand for Residential Broadband", Working Paper.

Rosston, G., S. Savage, and D. Waldman. 2010. "Household Demand for Broadband Internet in 2010", *The B.E. Journal of Economic and Policy Analysis (Advances)*, 10(1), Article 79.